The Planned Europa Mission: The Next Step in Exploring Habitability of an Icy World

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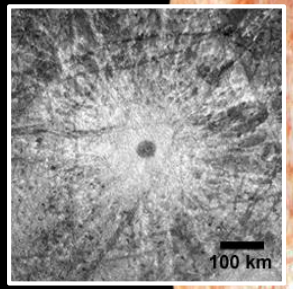
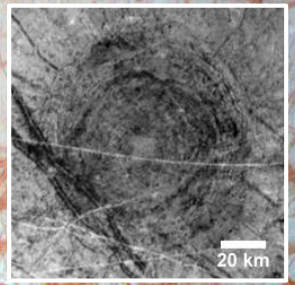
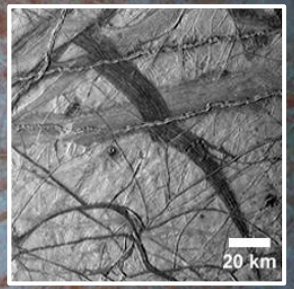
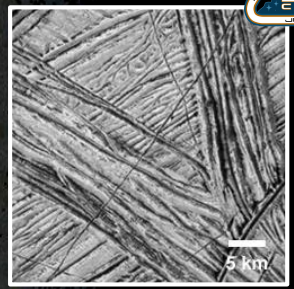
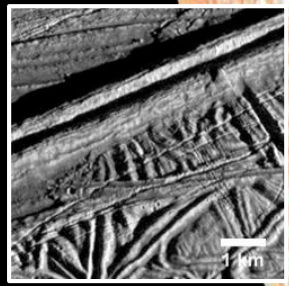
Europa: What a World, What of Life?

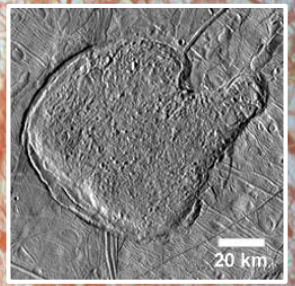


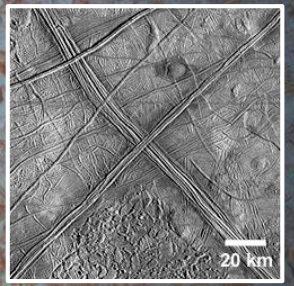


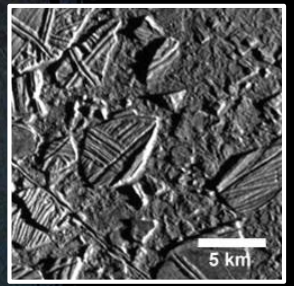


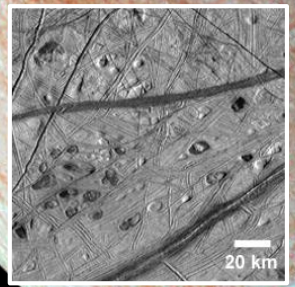


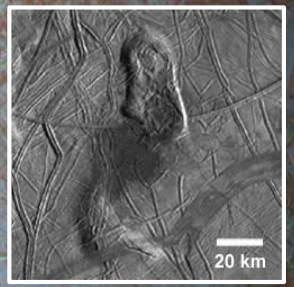


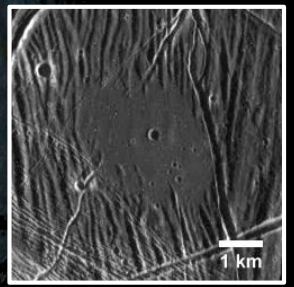






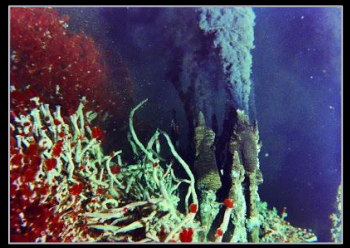




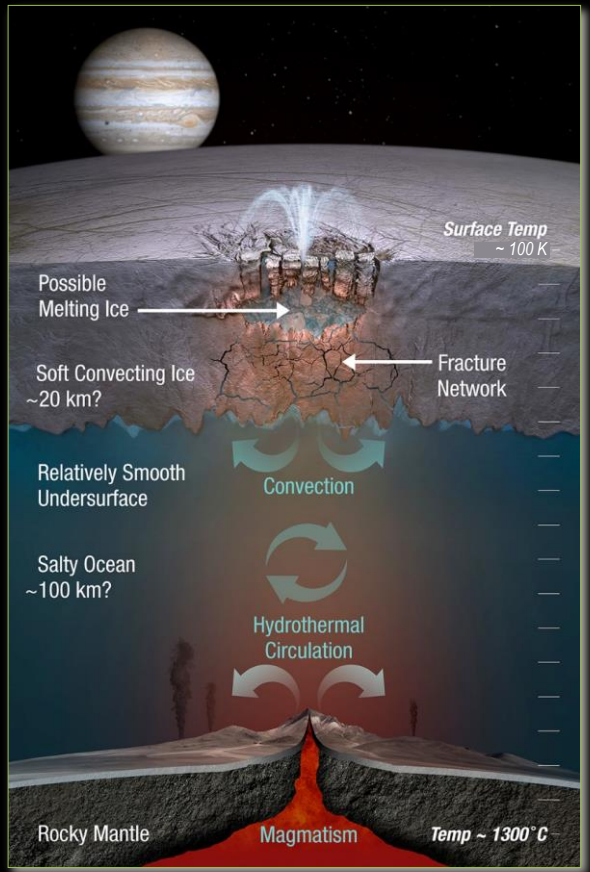


Europa: Ingredients for Life?

- Water
  - *More than 2x all of Earth's oceans*
- Essential elements
  - *From formation and impacts*
- Chemical energy
  - *Potentially from above and below*
- Stability
  - *Variable, but "simmering" for 4 By*

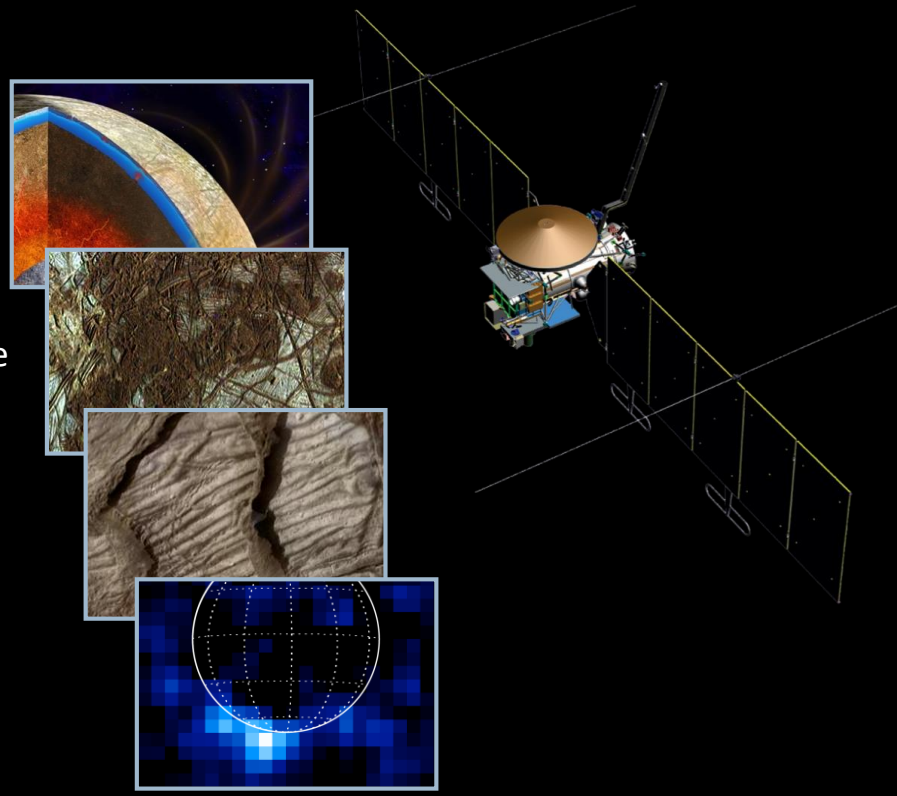


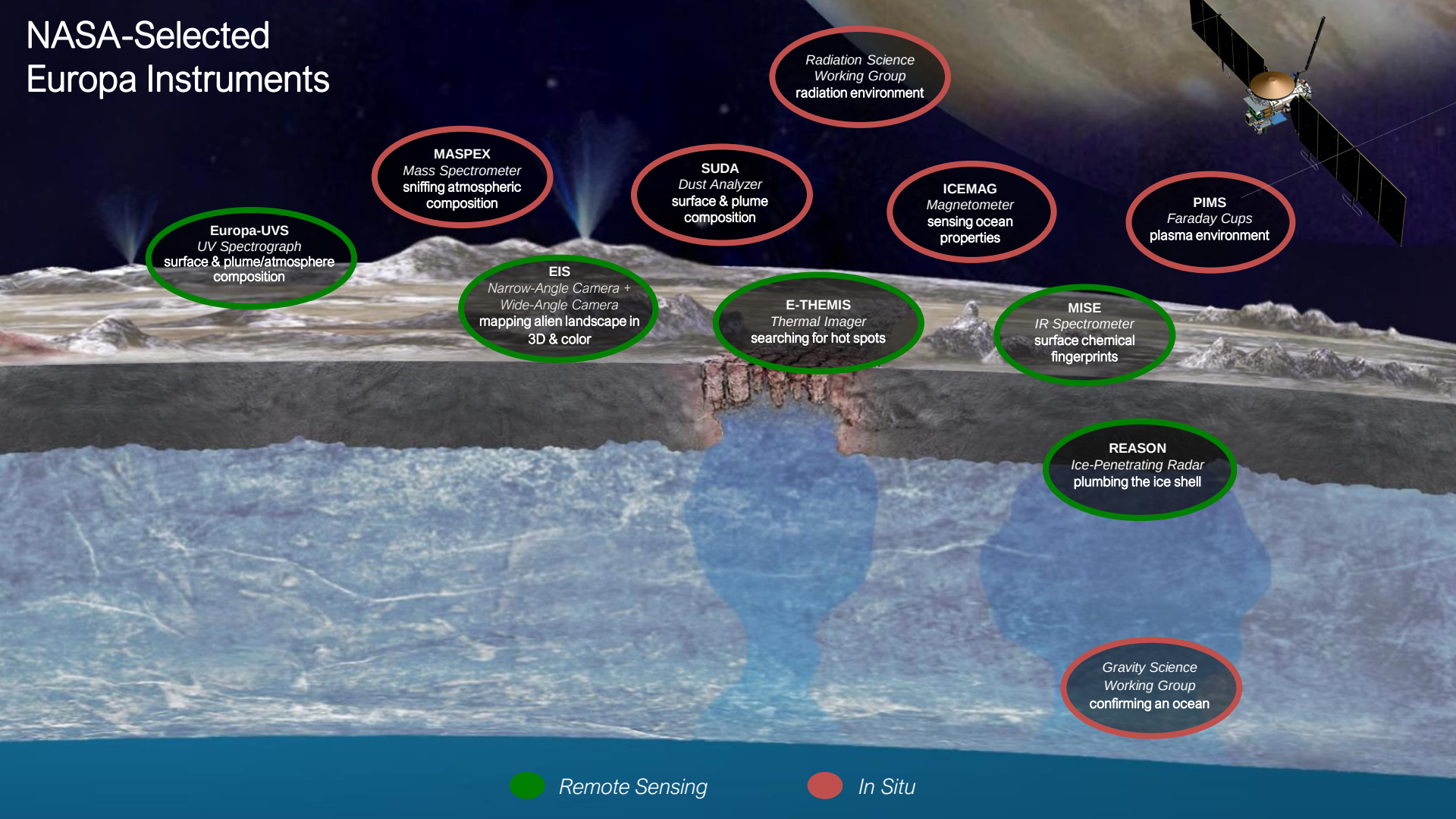
A Europa mission would verify key* habitability *hypotheses



Europa Clipper Science Goal & Objectives

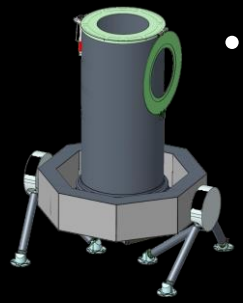
- *Mission Goal:* **Explore Europa to investigate its habitability**
- *Science Categories:*
  - **Ice Shell & Ocean:** Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange
  - **Composition:** Understand the habitability of Europa's ocean through composition and chemistry
  - **Geology:** Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities
  - **Current Activity:** Search for and characterize any current activity, notably plumes and thermal anomalies



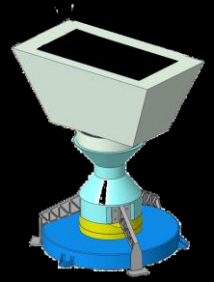

NASA-Selected
Europa Instruments
Radiation Science
Working Group
radiation environment
MASPEX
Mass Spectrometer
sniffing atmospheric
composition
SUDA
Dust Analyzer
surface & plume
composition
ICEMAG
Magnetometer
sensing ocean
properties
PIMS
Faraday Cups
plasma environment
Europa-UVS
UV Spectrograph
surface & plume/atmosphere
composition
EIS
Narrow-Angle Camera +
Wide-Angle Camera
mapping alien landscape in
3D & color
E-THEMIS
Thermal Imager
searching for hot spots
MISE
IR Spectrometer
surface chemical
fingerprints
REASON
Ice-Penetrating Radar
plumbing the ice shell
Gravity Science
Working Group
confirming an ocean
Remote Sensing
In Situ

Europa Instrument Highlights: EIS

Europa Imaging System (EIS): Zibi Turtle, PI

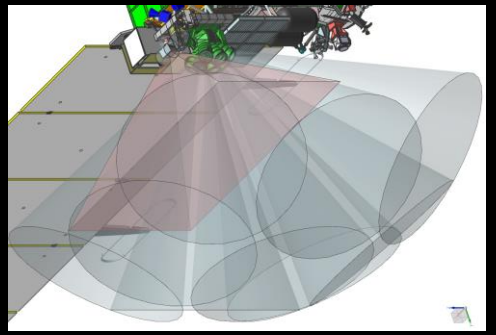


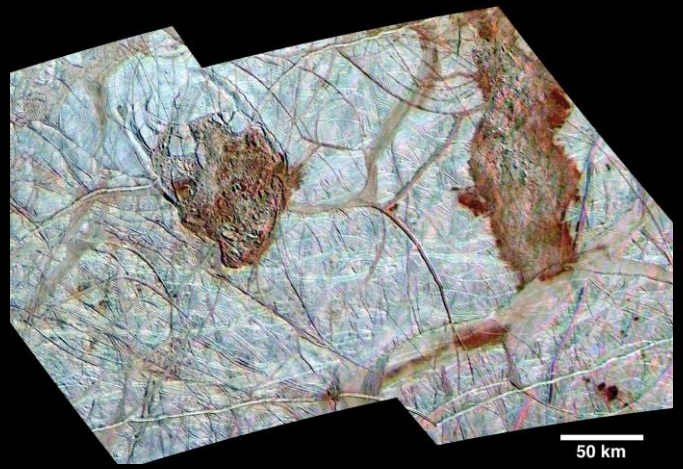
EIS-NAC



EIS-WAC

- Adding color capability to NAC
  - Scattered light analysis shows that addition of color stripe filters will not impede plume detection
  - Increases opportunities to gimbal-target coordination with other instruments, extrapolating to small scales and other regions
  - 10 m color resolution from 1000 km
  - Can join the “joint scan” planned for each flyby giving 200 - 400 m/pixel hemispheric color
  - Extrapolate composition information to smaller scales and other regions



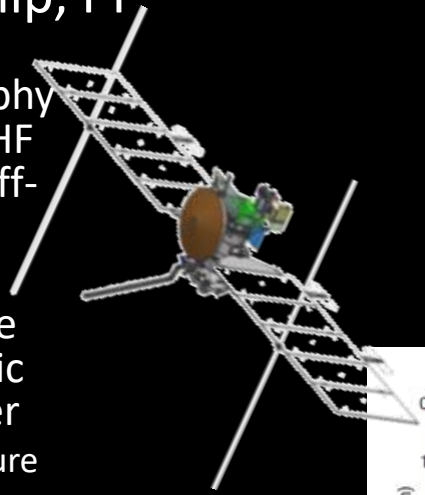


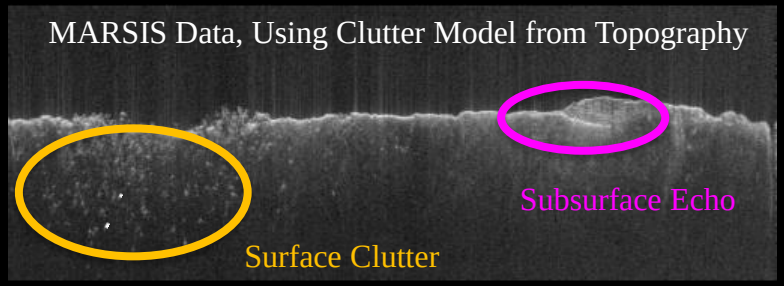
Thera & Thrace: Galileo 220 m/pixel combined with 1.4 km/pixel color

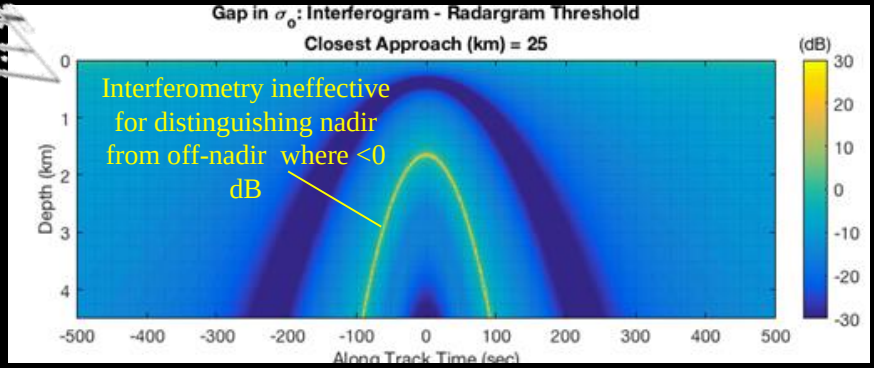
Europa Instrument Highlights: REASON

Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON): Don Blankenship, PI

- REASON can use both topography from EIS stereo imaging and VHF interferometry to distinguish off-nadir-surface from subsurface reflectors
- Developed tools to quantify the suppression and interferometric discrimination of surface clutter
  - Assists spacecraft design and future analyses
- Helps to clarify issues affecting REASON performance, esp. below 50 km





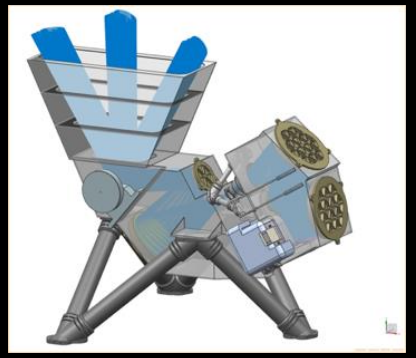


Europa Instrument Highlights: MISE

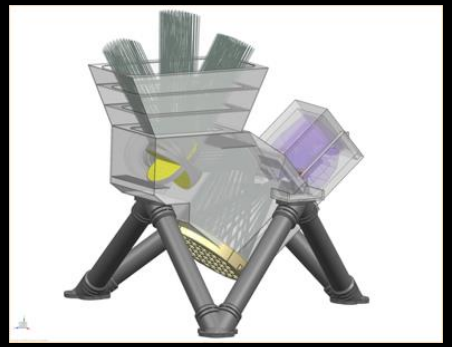
Mapping Imaging Spectrometer for Europa (MISE): Diana Blaney, PI

- Thermal accommodation is critical to MISE
  - Cryocooler performance testing is currently underway
- Changed from Offner to Dyson spectrometer design, permitting reduction from 2 to 1 cryocooler
  - Reduces instrument mass, energy, cost
  - More compact, so less to cool
  - Greater light gathering improves S/N
  - No change to spectral range or requirements

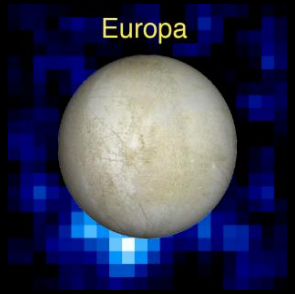
Offner Architecture



Dyson Architecture

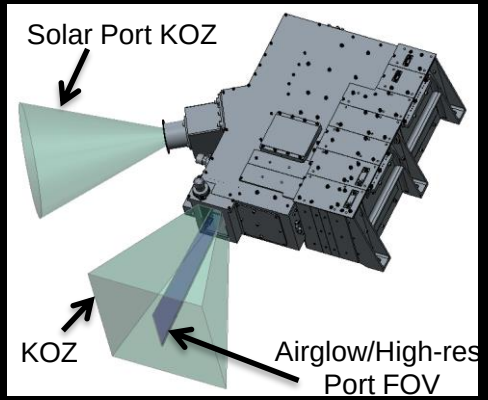


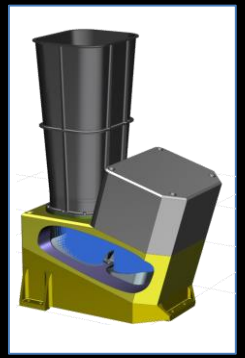
Europa Instrument Highlights: Europa-UVS & E-THEMIS



Europa Ultraviolet Spectrograph (Europa-UVS): Kurt Retherford, PI

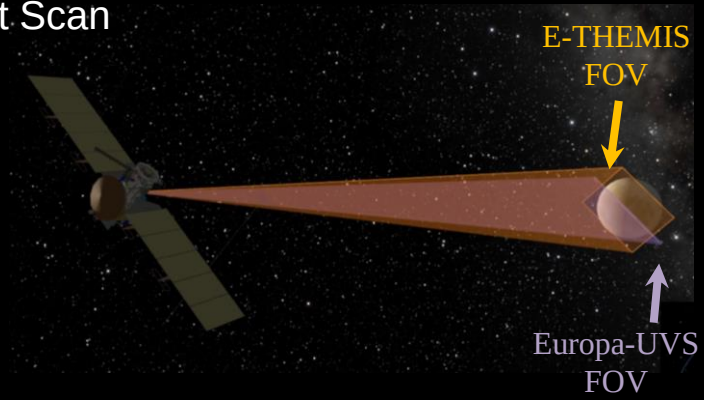
- Working design to reduce angle to solar port, to permit smaller turns for solar occultations, while avoiding sun on SUDA
- Designing open/close solar port door actuator





Europa Thermal Imaging System (E-THEMIS): Phil Christensen, PI

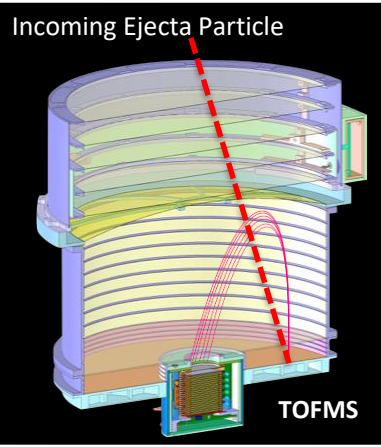
- Detector selected
- Spacecraft scanning permits observing a range of local times of day on the surface



Europa Instrument Highlights: SUDA & MASPEX

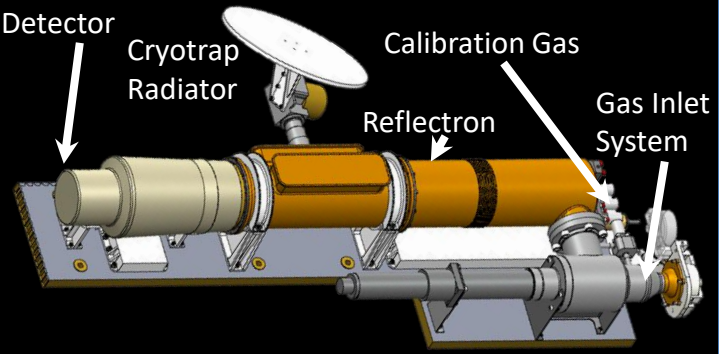
SUrface Dust Analyzer (SUDA): Sascha Kempf, PI

- SUDA is oriented directly into dust ram at closest approach, when particle number density is highest
- Sun must be out of FOV while making dust measurements
- Improving TRL on Ir-coated detector through prototype testing
- Investigating innovative ways to lower instrument mass

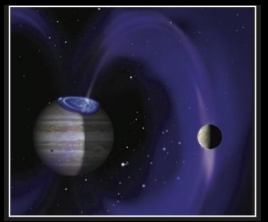


MAss Spectrometer for Planetary EXploration (MASPEX): Hunter Waite, PI

- VAT valve to reduce leak rate, facilitating cryosample analysis
- Performing lifetime testing on ion pump
- Fabricating parts for detector
- Contamination control is key
  - spacecraft cleanliness, FOV/KOZ incursions, thruster products

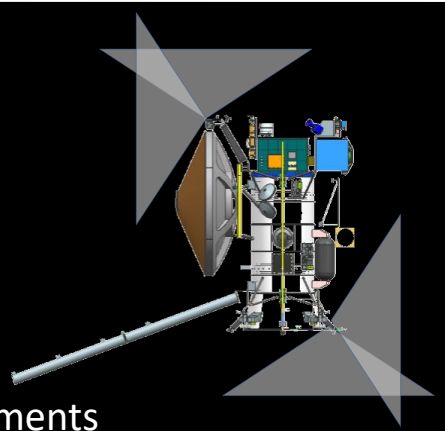


Europa Instrument Highlights: PIMS &ICEMAG

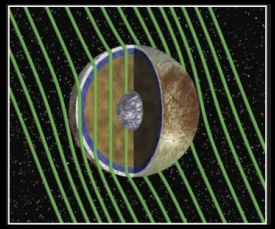


Plasma Instrument for Magnetic Sounding (PIMS): Joe Westlake, PI

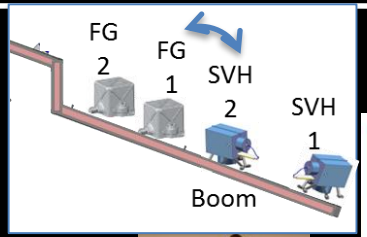
- 2 sensors, each with 2 Faraday cups (90° FOV each)
- Moved electronics to within cups, improving grounding
- Modeling demonstrates mag cleanliness can be relaxed
- Developing tools to assess potential science impacts of spacecraft charging, which can affect ion or electron measurements

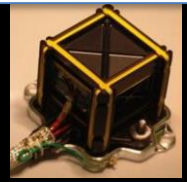


Interior Characterization of Europa using Magnetometry (ICEMAG): Carol Raymond, PI

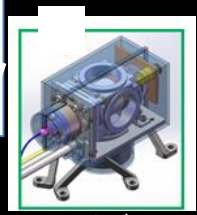


- Optimized location on the boom of the FG and SVH sensors
- Working with spacecraft team on sensor attitude knowledge and magnetic cleanliness requirements



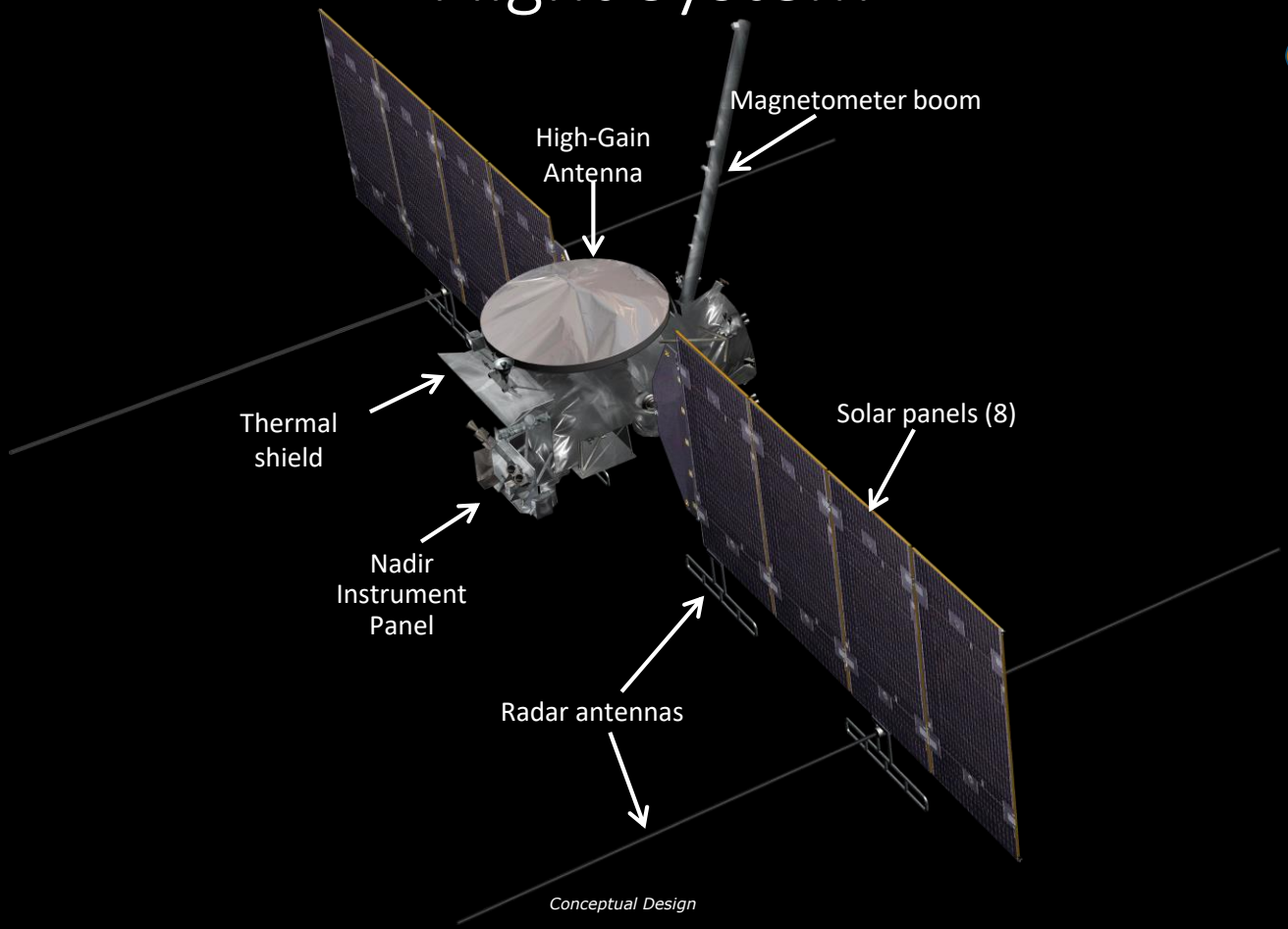


2 x Flux Gate (FG): vector



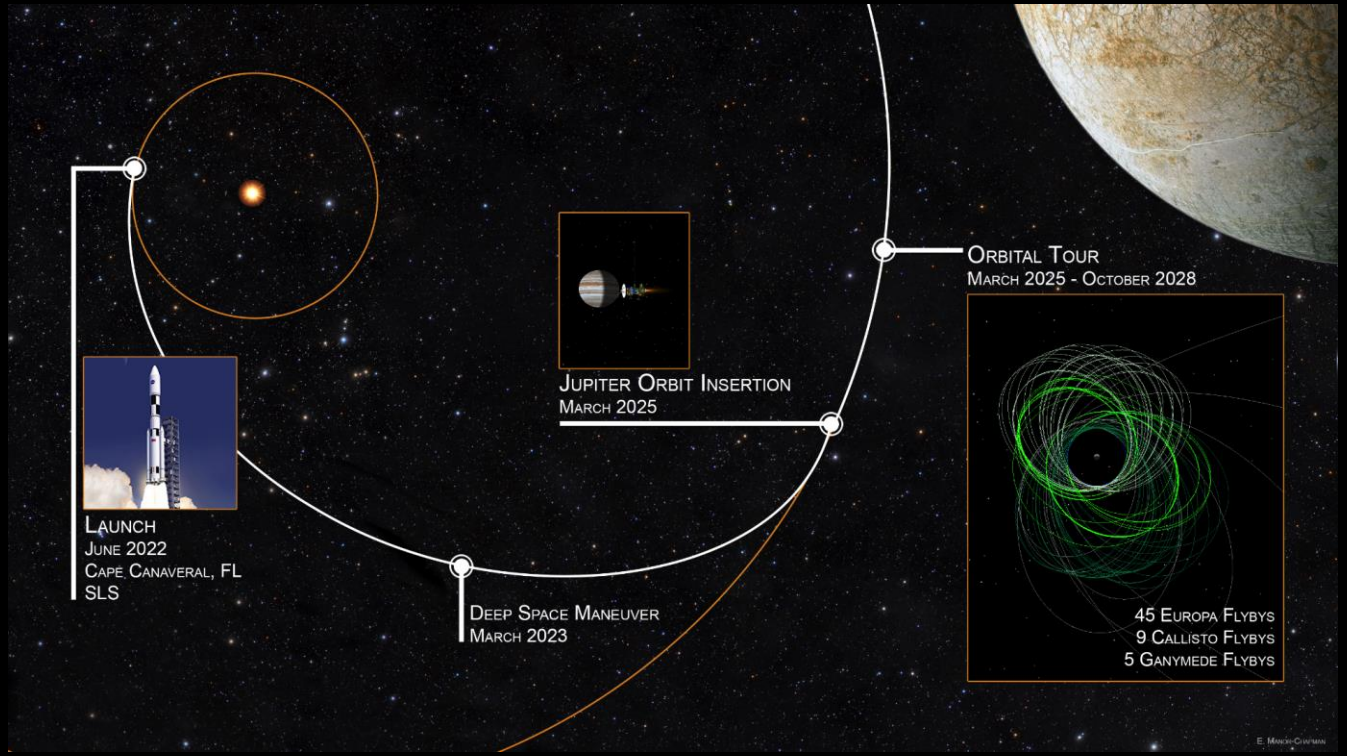
2 x Scalar/Vector Helium (SVH): alternating scalar and vector

Flight System



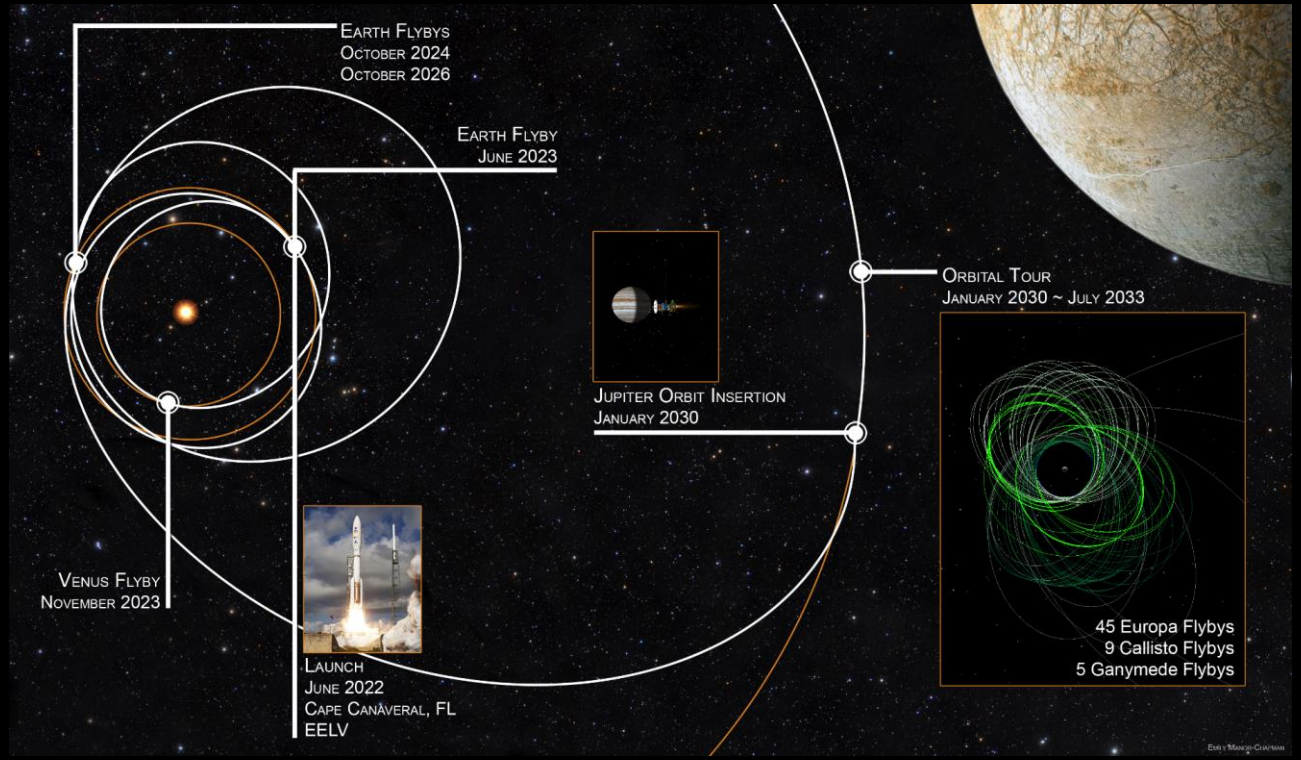
Conceptual Design

Launch and Cruose to Jupiter, Option A (SLS Launch): Direct-to-Jupiter Trajectory & Jovian Tour



Transit to Jupiter ➔ 2 years, 9 months

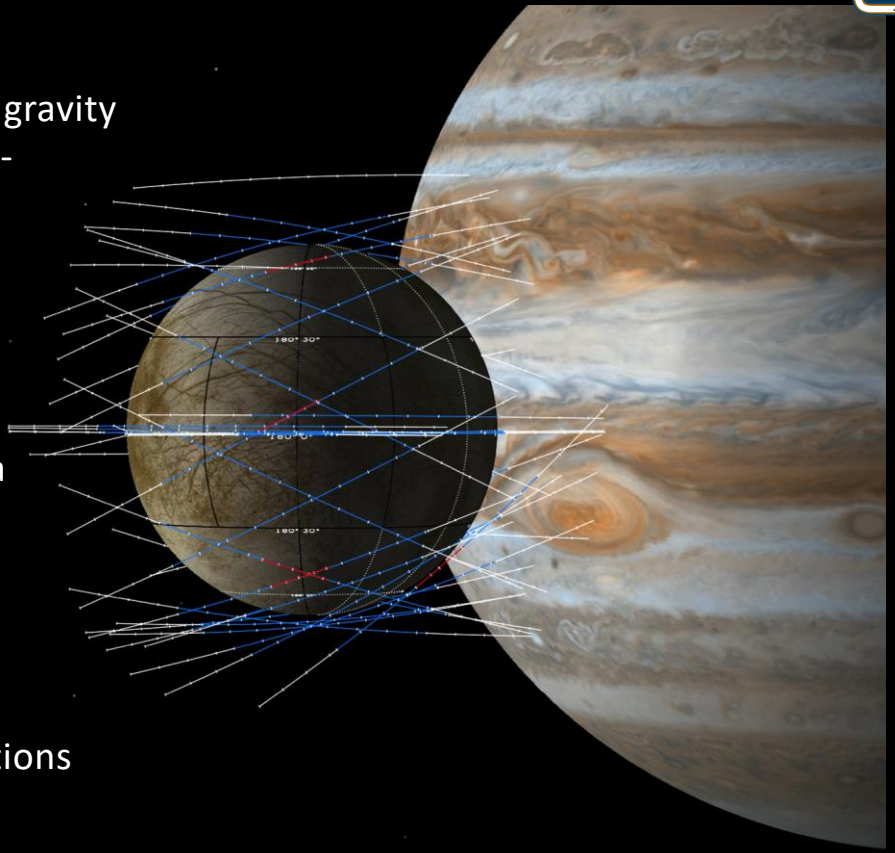
Launch and Cruise to Jupiter, Option B (EELV Launch): EVEEGA Trajectory and Jovian Tour



Transit to Jupiter ➔ 7 years, 7 months

Mission Concept

- Utilize multiple satellite gravity assists to enable “global-regional coverage” of Europa while in orbit around Jupiter
- Current mission design consists of ~45 low-altitude flybys of Europa in prime mission from Jupiter orbit over 3.5 yr
- Minimizes time in high-radiation environment
- Simple repetitive operations



The Path Forward

- A highly capable spacecraft and payload to address key questions regarding potential habitability
- Upcoming Project Milestones:
  - Flight System PDR, 17-20 October 2017
  - Instrument PDRs, November 2017 to May 2018
  - Project PDR, August 2018